Space Technology Research Grants

Development of a Mechanically Versatile Bioreactor System as a Cellular Microgravity Countermeasure for Regenerative Medicine Applications

Completed Technology Project (2014 - 2018)

Project Introduction

The primary objective of this research project is to develop a compact, mechanically versatile bioreactor capable of producing desired local mechanical environments to stimulate optimal cell proliferation, differentiation and tissue formation for a wide range of regenerative medicine applications in microgravity. Specifically, I aim to develop a novel strategy using time-varying magnetic fields to manipulate magnetic “handles” embedded within a deformable substrate or scaffold, thereby allowing a wide range of local mechanical environments to be produced using a single device with minimal moving parts. Mechanical unloading due to microgravity has detrimental effects on a range of cellular behaviors, and the lack of appropriate cell- and tissue-level stresses is expected to impair healing of musculoskeletal injuries as well as reduce the viability and effectiveness of native stem cells that normally participate in repair and regeneration. The proposed system will facilitate the development and refinement of countermeasures to maintain the endogenous population of stem cells required for normal tissue renewal and healing in space and could constitute a primary component of an astronaut stem cell replacement mechanism to be used during missions. Early stages of the project will focus on the integration of magneto-mechanical stimulation to produce a highly robust loading system that can produce mechanical environments optimized for various cell types. An initial line of work will involve embedding small magnetic “handles” into a layered, paper-based scaffold and developing a properly-shielded magnetic control system to manipulate the scaffold to produce a range of time-varying loading states. Modeling approaches will be used to determine the optimal placement of the handles and optimal activation patterns for external magnetic fields to achieve loading modes hypothesized to be necessary for healthy cell behavior. Later stages of the project will focus on packaging the bioreactor system for integration into existing space vehicle confines and common power consumption limits as well as integrating it with existing bioculture systems, to promote a constant sterile environment for the cells.

Anticipated Benefits

Overall, this work would inspire the generation and implementation of human health space technologies and would support NASA-identified goals regarding long-duration human health and performance in space with respect to exercise and exercise equipment.

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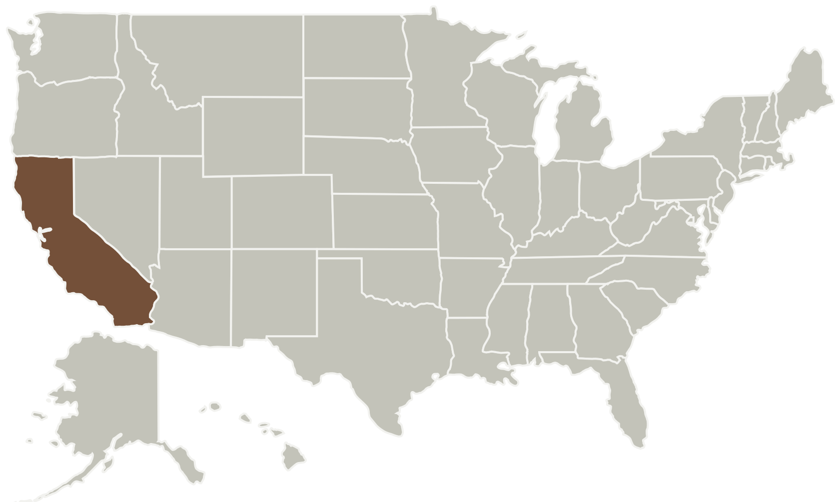
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Stanford University(Stanford)	Lead Organization	Academia	Stanford, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Stanford University (Stanford)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Marc Levenston

Co-Investigator:

Aliyeh Mousavi

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - └ TX06.3 Human Health and Performance
    - └ TX06.3.2 Prevention and Countermeasures

Target Destinations

The Moon, Mars, Earth